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November 30, 2020

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: *Ex Parte* **Presentation,** *Unlicensed Use of the 6 GHz Band,* ET Docket No. 18-295

Dear Ms. Dortch:

Throughout this proceeding, CTIA has expressed support for introducing unlicensed operations in 6 GHz spectrum, provided that a robust interference protection regime protects incumbent licensed operations in the band, including public safety, utility, and wireless backhaul links. The Commission adopted the Automated Frequency Coordination ("AFC") system for unlicensed standard power devices but declined to extend the AFC system—or any effective interference mitigation mechanism—to low power indoor ("LPI") devices.[1] The Further Notice proposes to expand untethered unlicensed operations in the band to a new class of AFC-free "very low power" ("VLP") devices that can operate anywhere, outdoors or indoors. CTIA continues to oppose these AFC-free operations, which will inevitably cause harmful interference to incumbent licensed operations.

CTIA recently submitted a 6 GHz test report showing that a single LPI device transmitting as far as 9 km away can cause interference to a licensed Fixed Service ("FS") link in the band.[2] The real-world testing further shows that a VLP device can cause interference when transmitting as far as 2 km away. These field tests add to the link budget analysis CTIA submitted in its reply comments, assessing the impact on five incumbent FS links and demonstrating that a single unlicensed device operating in the vicinity of the sample

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[1] *Unlicensed Use of the 6 GHz Band*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 3852 (2020) ("6 GHz Order" and "Further Notice" as appropriate).

[2] CTIA, 6 GHz Field Test Report at 14 ("CTIA Test Report") (attached to Letter from CTIA to FCC, ET Docket No. 18-295 (filed Nov. 13, 2020)).

locations studied poses a material risk of harmful interference.[3]   Even the RLAN proponents' favored study, the RKF VLP Study,[4] shows that individual VLP device operations will cause interference well in excess of the interference threshold, -6 dB I/N, to more than 10,000 FS links—that is, to over 10 percent of existing FS links.[5]   These results demonstrate that a single VLP device would present a serious risk of harmful interference to critical FS links in the band.

But the RLAN companies continue to rely on RKF analyses that ignore the sheer volume of single device interference events and focus solely on misleading statistical analyses derived from too few test cases.[6]   RKF's analysis only considers simultaneously operating devices in a snapshot in time and dramatically understates the risk of harmful interference.

Below we highlight some of the key flaws in the recent RKF response, first contrasting RKF claims with facts and then exploring key missteps in the RKF VLP Study.

The RKF Letter Continues to Make Claims That Are Not Supported by the Facts.

- **RKF Claim:** When a Monte Carlo analysis simulates low probability occurrences, one must conclude that such cases are unlikely to occur in the real world.[7]

- **Fact:** The probability must be viewed in the proper context and adjusted to represent the real-world situation. When low probability from a small-scale simulation is multiplied across the hundreds of millions of anticipated unlicensed devices and nearly 100,000 existing FS links, then what initially appear as low probability events become statistical certainties. By RKF's own flawed calculations, 10,000 or more FS stations will be impacted at a threshold of I/N >= -6 dB.[8] This is not extremely rare, contrary to the RLAN companies' claim.[9]

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[3] Reply Comments of CTIA, GN Docket No. 17-183, et al. (filed July 27, 2020) ("CTIA Reply Comments"); *6 GHz VLP Interference*, CTIA (July 2020) (attached to CTIA Reply Comments") ("CTIA Link Budget Analysis").

[4] RKF Engineering Solutions, LLC, Frequency Sharing for Very Low Power ("VLP") Radio Local Area Networks in the 6 GHz Band (June 29, 2020) ("Jun. 29 RKF VLP Study") (Attachment A to Apple/Broadcom et al. Comments).

[5] RKF claims probability of interference per FS is 0.00011% based on 100,000 iterations (0.11 occurrences per FS per 100,000 iterations) (Jun. 29 RKF VLP Study at 29). Multiplying that rate (0.11) by 97,888 FS links means that there are 10,768 total occurrences of I/N > -6 dB per 100,000 iterations.

[6] Letter from RKF Engineering, et al. ("RLAN Companies") to Marlene H. Dortch, GN Docket No. 17-183, et al. (filed Oct. 16, 2020) ("Oct. 16 RKF Letter").

[7] *Id*. at 2.

[8] Jun. 29 RKF VLP Study at 30.

[9] Oct. 16 RKF Letter at 2.

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• **RKF Claim:** A 10% increase in link unavailability is not "harmful interference."[10]
• **Fact:** A 10% increase in link unavailability will substantially increase outages and degrade performance of existing links. This level of risk is unacceptable for critical services including 9-1-1 calls, public safety operations, and utilities, which are entitled to interference protection from unlicensed uses.[11] Incumbent licensees have invested heavily in their networks to acquire this level of reliability because their operations require it, and unlicensed operations have an obligation not to cause harmful interference. With hundreds of millions of unlicensed devices anticipated in the band and no established mechanism for licensed operators to seek recourse once harmful interference occurs, this acknowledged 10% increase in unavailability is all the more problematic.
• **RKF Claim:** The RKF Study included scenarios with line-of-sight ("LOS") path losses with no clutter at the full range of VLP-to-FS distances.[12]
• **Fact:** Despite RKF's claim, the RKF Study included clutter at all distances beyond 30 meters, even when the VLP transmitter is in clear line of sight to the FS receiver.[13] The RKF Study uses the Combined LOS/NLOS Winner II model from 30 meters to 1 km, and as the FCC noted in its 6 GHz Order, "the WINNER II model accounts for obstructions by urban and suburban clutter."[14] Thus, an entire category of scenarios with the highest risk of harmful interference—LOS operations in the vicinity of FS links—is completely ignored by the RKF simulations.
• **RKF Claim:** The Monte Carlo approach is the most appropriate means to determine the probability and magnitude of interference events occurring in the real world.[15]
• **Fact:** A single link budget is a better analytic tool when analyzing interference where interference is dominated by a single device.[16] Although Monte Carlo analyses can in some circumstances be useful, a valid simulation requires a sufficient number of test cases to achieve a degree of confidence that all realistic scenarios are being evaluated, especially in cases where real-world examples have been provided that

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[10] *Id*. at 3.

[11] CTIA Reply Comments at 17.

[12] Oct. 16 RKF Letter at 3.

[13] Jun. 29 RKF VLP Study at 16-17.

[14] 6 GHz Order ¶ 65.

[15] Oct. 16 RKF Letter at 3.

[16] The ECC Report 302 employed both minimum coupling loss studies (link budget assessments) and Monte Carlo simulations.

> show actual interference. Indeed, even RKF's own data shows that the I/N of -6 dB criteria will be exceeded in 10,000 or more cases.

RKF's Monte Carlo simulation is fatally flawed. Monte Carlo simulations draw from distribution curves for a number of variables to provide insight into the likelihood of various outcomes. Simulations must reflect the scale of the problem under investigation to convey the true probabilities of the situation. A well-implemented Monte Carlo simulation can make an important contribution to interference analysis, but the RKF analysis uses flawed modeling that renders its conclusions misleading and irrelevant. As a result, the RLAN Companies' filings continue to severely understate the likelihood that harmful interference will occur from hundreds of millions of untethered LPI and VLP devices.

Lotteries and the likelihood that someone will purchase a winning ticket offer a useful analogy. In a lottery, the chance that any single individual ticket will win the lottery is low. This individual chance remains low whether 100 or 100,000,000 lottery tickets are purchased. However, collectively, the odds that *someone* will win the lottery are significantly higher the more tickets are purchased. Similarly, while the likelihood that a particular LPI or VLP device will cause harmful interference may be low, the likelihood of harmful interference to a fixed link increases significantly as more LPI and VLP devices are introduced into the band. RKF ignores the fact that *low probability events are practical certainties when hundreds of millions of untethered unlicensed devices are introduced into a band with nearly 100,000 incumbent links*.

As noted above, CTIA's earlier filings illustrate real-world examples where harmful interference will occur.[17] And the recent 6 GHz test report confirmed that a microwave link can experience harmful interference from just one VLP or LPI transmitting device.[18] On any given day, hundreds of millions of devices will be transmitting, each with the potential to interfere with an incumbent system.

However, the RKF VLP Study uses low duty cycle assumptions and minimally active devices to artificially reduce the projected number of simultaneously transmitting devices to an unrealistically low number – 4,417 outdoor VLP devices. But all VLP devices will, at some point, be transmitting. In this manner, RKF models a very small number of devices, for a

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[17] CTIA Link Budget Analysis.

[18] CTIA Test Report at 14.

small sliver of time, and claims that this model quantifies the totality of all risk. But as shown above, in the real world there will be hundreds of millions of VLP devices each capable of causing harmful interference into any of the approximately 100,000 incumbent licensees in the 6 GHz band. As a result, the RKF simulations dramatically undercount the likelihood of harmful interference.

The RKF methodology is akin to assessing the likelihood that there will be a lottery winner based on the number of tickets sold simultaneously (4,417) even though hundreds of millions of lottery tickets are purchased.

RKF's statistics are fundamentally flawed. Approaching the RKF simulations from another angle will help to illustrate the fundamental flaws in the approach. When RKF calculates the probability of interference occurrence per FS link, RKF divides the number of interference occurrences by the number of iterations.[19] Thus, the probabilities cited are the probabilities within one simulation iteration, in which a few devices were dropped within a finite time period. RKF chose to drop a low number of devices in the simulation to ensure the outcome showed a low probability of interference. To illustrate this concern, consider a hypothetical case where, in one iteration, all 4,417 devices – 100% percent of the devices – each interfere with a different FS link. The total FS links that would be receiving interference in that simulation run would be 4,417. However, RKF would then divide that result by the total number of FS links (97,888) to conclude the risk of interference to a FS link is 4.5%. This outcome could be construed as favorable – "only" 4.5% of FS links received interference in that iteration. But in this example, it is clear that the statistics do not adequately describe the situation – all unlicensed devices are causing interference, but the simulation is set up to appear benign given the very low numbers of devices assessed relative to the number of FS links. The RKF simulations result in similarly misleading statistics. Simulating such a low number of devices against a high number of FS links artificially deflates the stated effect of those devices causing interference.

In reality, the Monte Carlo Simulation shows a high likelihood of interference.
RKF provides an extended analysis of a receive link, call sign WQUG258, and claims the

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[19] Jun. 29 RKF VLP Study at 25.

probability that this FS link will experience interference is 0.014%.[20] Importantly, RKF calculates the probability of occurrence by dividing the total instances of interference across all iterations by the number of iterations – 100,000. Such an approach only indicates the probability of interference occurring in one iteration, for the small number of devices modeled – as the RLAN companies say, for "a snapshot in time."[21]

A more useful approach is to translate this probability of occurrence per FS link in one snapshot into the annual number of interference events expected to occur for that link. For example, applying a timescale to RKF's analysis would suggest an interval based on the 0.44% duty cycle.[22] This duty cycle is the amount of time assessed by the simulation during one busy hour, and equates to 15.84 seconds (0.44% x 60 minutes/hour x 60 seconds/minute = 15.84 seconds). However, the risk to incumbents is not limited to a 16 second interval, or even to one hour per year. The number of "snapshots" that exist in one year must be calculated in order to understand the risk to a given FS link. In one year, there are 31,560,000 seconds. Therefore, in one calendar year, 1,992,424 snapshots occur.[23] The potential impact to one FS link from unlicensed operations over the course of one year is calculated by multiplying the FS link probability of occurrence in one snapshot by the number of snapshots per year: (0.00014 x 1,992,424) = 279. In other words, the study shows that harmful interference from VLP devices will occur to this one FS link 279 times per year, or about once every 32 hours.[24] Experiencing harmful interference every 1-2 days is not at all a "rare occurrence" and is solidly within the Commission's definition of harmful interference – *i.e.*,

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[20] *See* Letter from Apple Inc., Broadcom Inc., et al to Marlene H. Dortch, FCC, ET Docket No. 18-295, at 8, Table 3, first row (filed Oct. 6, 2020) ("Oct. 6 RLAN Letter").

[21] *Id.* at 7 ("Note that the denominator is the number of iterations, not the number of VLP devices. Thus, [the equation] provides the probability that there is an occurrence of I/N greater than an I/N$_{threshold}$ for a particular FS at a snapshot in time.").

[22] If device duty cycle is longer, then the 4,417 devices RKF calculated would be a much larger number, with a higher starting probability of interference. Notably, while the Oct. 6 RLAN Letter advocated for a 2% duty cycle, the VLP Study appears to rely on the 2018 RKF inputs, and thus employs a 0.44% duty cycle.

[23] Number of snapshots = 31,560,000 / 15.84 = 1,992,424.

[24] As AT&T has noted, it is appropriate to "use[] the term 'harmful interference' to denote, consistent with the Commission's historic protection of primary FS services, exceeding a -6 dB I/N protection ratio. *See, e.g.*, C-Band Order, 35 FCC Rcd at 2475-76 (¶ 363); Higher Ground LLC, Order and Authorization, 32 FCC Rcd 728 (2017)." *See* Letter from AT&T Services, Inc. to Marlene H. Dortch, FCC, ET Docket No. 18-295, at 10 n.50 (filed Nov. 18, 2020).

interference that seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service.

The duty cycle employed in the Monte Carlo simulations is unrealistically low. The projected 279 instances of interference to one FS link will increase dramatically as more realistic duty cycles are considered. Now, consider the possibility that RKF's 0.44% duty cycle is dramatically understated. If taken at face value, RKF considers only the data payload in this percentage, dividing the application bit rate by the throughput of the link. All wireless technologies, including Wi-Fi, require the transmission of control information to manage the link. A payload of 0.44% of data would still require physical layer framing, medium access control overhead, and Internet Protocol overhead to transport the user data. When evaluating the potential for interference, any RF emission must be considered – not just the portion of the wireless signal which the interfering party considers to be payload. RKF's simulations are drastically underestimating interference because the duty cycle does not reflect the actual wireless transmission time, which is what causes interference.

RKF also assumes an optimistic denominator in the duty cycle calculation, using a Gbps "over-the-air" throughput. However, when obstacles are between the transmitting VLP device and the receiver, then the link throughput will be reduced, resulting in a higher duty cycle. Furthermore, if the "backhaul link" back to the Internet is not Gbps capable, then the over-the-air rate will likewise be slower, increasing duty cycle further. And certain applications are more efficient to transport than others. While data from large file downloads can be efficiently packed into radio frames, interactive and latency sensitive applications must send data more frequently, reducing the frame packing efficiency – and increasing the duty cycle because more radio frames are occupied. All of these factors, combined with the PHY, MAC and IP layer overheads, means the VLP duty cycle will be closer to 30% than 0.44%.[25]

Furthermore, new uses and applications are emerging daily that are constantly increasing the data load of wireless devices. The RLAN community itself noted that the HD AR/VR application would require 400 Mbps.[26] Applying this data rate against RKF's recent

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[25] While higher duty cycles will impact the interference probabilities, it is important to recognize that a low duty cycle does not provide protection from interference. The 6 GHz Test Report noted similar levels of interference to incumbent FS operations regardless of the duty cycle setting.

[26] Apple/Broadcom et al. Comments at 12.

duty cycle math would result in a 40% duty cycle, nearly one hundred times greater than the duty cycle modeled by RKF.[27] AR/VR applications will increase VLP usage—and in unexpected locations. An example of real-world conditions creating unexpected challenges for networks is the impact that Pokémon Go had on networks when the game was introduced in 2016. The game greatly increased mobile data usage and changed network traffic patterns as players attempted to capture Pokémon outside.[28] An equally compelling future application could greatly increase anticipated outdoor VLP usage – both in data load and in percentage of outdoor time - and place incumbent 6 GHz licensed services at a significantly greater risk.

The VLP transmission power employed in the Monte Carlo simulations is unrealistically low due to use of a flawed distribution curve. The RKF study begins with the full VLP EIRP of 14 dBm, but then greatly reduces the net power according to a "far-field gain" curve derived from chamber measurements by the Wireless Research Center of North Carolina.[29] The curve in question shows the cumulative distribution function (CDF) of the net antenna gain toward the far-field – *i.e.*, toward an incumbent link – but incorrectly developed the CDF by integrating the entire sphere of measurements. The entire sphere includes the nulls of the antenna and captures many data points of poor antenna performance. This is important because these nulls, typically pointing toward the sky or the ground, would not be oriented toward the incumbent systems – instead, the "main lobe" patterns would generally point toward the FS receivers, with significantly higher gain.

To highlight the potential impact on the study's results, the CDF curve used by RKF means that the study only assesses the impact of 1% of VLP devices transmitting at the full EIRP in the direction of the FS links. In the study, about half of VLP devices would transmit with a power reduction of 15 dB or greater, a sizable reduction.

A proper CDF limited to the realistic VLP pointing angles would show a much greater probability of high antenna gain, which would significantly increase the interference power considered across the simulated set of devices. RKF's choice to employ the flawed CDF

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[27] Oct. 6 RLAN Letter, page 5, footnote 18, derived an average active duty cycle of 2.2% = (22 Mbps / 1 Gbps). Using this same math, the RLAN HD AR/VR duty cycle becomes (400 Mbps / 1 Gbps) = 40%.

[28] Nick Statt, *Pokémon Go uses little data, but it's still a big drag on mobile networks*, The Verge (Jul. 15, 2016), https://www.theverge.com/2016/7/15/12201418/pokemon-go-mobile-network-performance-data-use.

[29] *Wireless Research Center of North Carolina Report On-Body Channel Model and Interference Estimation at 5.9 GHz to 7.1 GHz Band* at 9 (Attachment B to Apple/Broadcom et al. Comments).

greatly dilutes the effective VLP EIRP in the study and significantly underestimates the probability of interference to licensed incumbent FS operations.

The RLAN companies have not shown that VLP operations can protect licensed incumbent FS operations from harmful interference. The underlying problem with the RKF simulations is that it fails to represent the real-world situation as the RLAN companies project. Hundreds of millions of unlicensed 6 GHz devices will be deployed across the country, and will transmit on a daily basis, with each individual device capable of causing harmful interference to licensed incumbent FS operations. Any reliance on interference probabilities must be adequately extended to the correct device population and timescale to be meaningful. Moreover, the RKF analysis only accounts for outdoor VLP operations, but LPI client devices operating outdoors[30] and indoor LPI access points will contribute additional emissions to any aggregate interference analysis. **The RLAN proponents have not submitted a comprehensive simulation including all types of unlicensed interferers to calculate the cumulative and aggregate interference risk.**

The significant interference threat posed by untethered unlicensed devices will create a substantial burden on licensees and the Enforcement Bureau staff who will be charged with investigating and resolving these interference concerns, without any insight into which device may be the cause of the interference or any ability to prevent the same or a different mobile VLP device from causing interference in the future. For illustrative purposes, the Commission has invested significant resources into investigating 53 separate enforcement actions against unlicensed device operators causing interference in the 5 GHz band, where Terminal Doppler Weather Radar operates at 49 locations in the United States. The number of interference events involving FS incumbent licensees in the 6 GHz band will be exponentially higher given the larger number of stations and will be even harder or impossible to track down for itinerant VLP devices, draining resources for incumbents and the Commission alike, and disrupting critical communications in the meantime.

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[30] In reality, despite the Commission's requirement that LPI access points only operate indoors, as explained in previous CTIA filings, current consumer behavior and Wi-Fi proponent advertising make clear that LPI access points will also operate outdoors. A realistic interference assessment would acknowledge and account for this inevitability.

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Pursuant to Section 1.1206 of the Commission's rules, this notice is being filed in ECFS. Please do not hesitate to contact the undersigned with any questions.

Sincerely,

/s/ Jennifer L. Oberhausen
Jennifer L. Oberhausen
Director, Regulatory Affairs

Doug Hyslop
Vice President, Technology and Spectrum Planning